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TOUCH-SENSITIVE OPTOELECTRONIC CIRCUITS AND INDICATORS

Thomas E. Bray, Clay, N.Y., assignor to General Electric Company, a corporation of New York
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The invention relates to novel touch-sensitive optoelectronic circuits which perform electrical and optoelectronic control functions and/or serve as visual indicators. These circuits are suitable for a wide range of applications generally coextensive with manually operated low power electrical switches and indicators. In the more complex applications such as keyboards, the circuits are adaptable to perform specialized functions such as key lock-out.

The common, manually operated, push button device is representative of the switches and indicators which are replaceable by the optoelectronic touch-sensitive circuits described herein. The term "touch-sensitive" is used to denote responsiveness to contact by a finger or thumb (generically referred to as "digits"), however, responsiveness to a digit generally results in responsiveness to any skin surface. A push button device consists of a mechanically displaceable element which typically operates a switch to close an electric circuit and thereby initiates or controls a machine operation. Often, these switches also rely upon the mechanical displacement of the push button as a visual indication of the operation of the switch. Push button devices, because of their mechanical nature, have inherent limitations. As in all devices which have mechanical motion, failure due to erosion, jamming, etc., can not be completely eliminated. When a large number of such switches are required, as in a desk calculator key board, there are difficulties in inexpensively manufacturing an array of manually operated switches and in providing reliable connections between the key board and electrical circuits operated thereby. A major source of these difficulties is the requirement for both mechanical and electrical elements and their operative relationship.

To overcome the limitations of a mechanical switch, manually operated switches have been developed which have no moving parts. These switches necessarily use the physical properties of the human body, such as its opaqueness to a light beam, to activate a switching device. The use of the electrical properties of skin is limited by the necessity for avoiding a shock hazard. However, a known type of switch which has been used for applications such as control of conventional lighting is the "Touchtron" manufactured by the General Electric Company. This device utilizes a gas discharge tube which is responsive to a voltage induced by the potential of a human body applied by digit contact to electrically control a switch. However, the "Touchtron" requires electrical connections with the controlled device similar to that of a push button operated relay and, because of the tube required, it is not readily adaptable to a printed-circuit type of device fabrication.

A visual indication of the manual operation of a push button (or similar device) is frequently desired at both the device itself and a display panel on which the condition of many manually operated devices are displayed. In a desk calculator, for example, the keyboard is comprised of an array of keys divided into columns corresponding to decimal orders. The operation of a key typically results in one of many numeral wheels on a display panel being rotatably displaced to a position indicative of which key was operated (in addition to initiating a calculator operation). An indicator which is equivalent to the numeral wheel is an array of fixed surface elements geometrically arranged in a plane so that the

surface presented by a selectable combination of elements is a numeral character. When the surface elements are electroluminescent or equivalent light radiating devices, and are arranged to be selectively energized, an indicator results which presents a variable display. This type of display is adapted to display other characters such as letters of the alphabet.

Electroluminescent elements are generally operated by an A-C. voltage source, typically 120 volts R.M.S. at 400 c.p.s. However, electroluminescent elements can be operated by voltage sources having frequencies from D-C. to thousands of cycles per second and over a substantial range of voltages. These elements have several desirable properties. They are very compact, normally fabricated as a deposited layer between a pair of electrodes and the fabrication readily takes the form of inexpensive printed circuit type techniques for both the conductors and the electroluminescent material. With a proper voltage source connected in series with a switch, the electroluminescent elements are inherent visual indicators of state for the switch.

Electroluminescent elements are also essential components of a class of electrical switching circuits which perform general digital logic operations. This class of switching circuits utilizes associated photoconductors and electroluminescent elements which are well adapted to perform relay type operations. Various survey articles have appeared in the literature describing these devices of which the following is an example: Proceedings of the IRE, Volume 47, No. 1, pages 4-11, January 1959 ("Photoelectronic Circuit Applications," by Sorab K. Ghandhi).

It is an object of the invention to provide a touch-sensitive circuit which is compatible with electroluminescent display devices and optoelectronic logic circuits and is suitable for general application including control of electronic circuits such as transistor logic circuits.

It is another object of the invention to provide a touch-sensitive circuit to serve as a manually operated indicator and/or switch suitable for general application which has no moving parts.

It is further object of the invention to provide a touch-sensitive circuit which does not present a shock hazard.

It is a still further object to provide an array of touch-sensitive circuits which are adapted to perform functions such as key lock-out and keyboard clearing operations.

It is another object of the invention to provide a touch-sensitive circuit which is well adapted to a printed circuit type of fabrication.

Briefly stated, in accordance with one aspect of the invention, a touch-sensitive optoelectronic indicator circuit is provided which utilizes an electroluminescent element, having a large impedance, to radiate light that serves as a control signal for associated photoconductor-electroluminescent circuits and/or provides a visual indication of state. The relation of light radiated to applied voltage for an electroluminescent element is characterized by a dark condition for low voltages and by an increasing amount of light radiation for increased voltages. A voltage source is provided which supplies a constant amplitude voltage exceeding the threshold level. A normally open, touch-sensitive switch is connected in series with the electroluminescent element and the constant voltage source to form a closed loop series circuit. Accordingly, the electroluminescent element is normally dark in the absence of activation by a digit contact. The touch-sensitive switch is comprised of fixed conductors which are separated by an insulator but which are arranged so that the separated conductors can be bridged by a digit in such a manner that the digit surface supplies a current path having an impedance that is small relative to the impedance of the electroluminescent element. When so bridged, this is